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## Effects of Physical Activity, Diet, & Self-Efficacy on Physical Function in Older Adults

Katlynn Mathis

University of Rhode Island, [katlynn\\_mathis@my.uri.edu](mailto:katlynn_mathis@my.uri.edu)

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EFFECTS OF PHYSICAL ACTIVITY, DIET, &  
SELF-EFFICACY ON PHYSICAL FUNCTION IN OLDER  
ADULTS

BY  
KATLYNN MATHIS

A THESIS SUBMITTED IN PARTIAL FULFILLMENT OF THE  
REQUIREMENTS FOR THE DEGREE OF  
MASTER OF SCIENCE  
IN  
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UNIVERSITY OF RHODE ISLAND

2016

MASTER OF SCIENCE THESIS  
OF  
KATLYNN MATHIS

APPROVED:

Thesis Committee:

Major Professor      Deborah Riebe

Mary L. Greaney

Phillip G. Clark

Nasser H. Zawia  
DEAN OF THE GRADUATE SCHOOL

UNIVERSITY OF RHODE ISLAND  
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## ABSTRACT

**Background:** Many older adults (OA) demonstrate decreased physical function (PF) which may lead to disability. Increased physical activity (PA), eating a healthful diet, and maintaining higher self-efficacy (SE) each improve PF in older adults, but few studies have examined if the combination of these three variables have an additive effect on PF. Additionally, few longitudinal studies have assessed the change in PF in relation to the changes in PA, diet, and SE. **Purpose:** The purpose of this study was to determine: (a) the relationship between PF and PA levels, fruit and vegetable intake (F&V), and exercise SE; (b) the percentage of variance in PF that is explained by PA levels, F&V intake, and exercise SE; and (c) if changes in PA levels, F&V intake, and exercise SE are related to changes in PF in community-dwelling OA. **Methods:** A secondary data analysis was conducted using data from the SENIOR II project. The participants (N=470) were community-dwelling OA ( $M=79.9$ ,  $SD=5.8$ ). PF was measured using the Timed Up and Go. F&V intake, PA and exercise SE were measured using the NCI Fruit and Vegetable Screener, the Yale Physical Activity Survey, and the Exercise Self-Efficacy Scale, respectively. **Results:** Pearson's  $r$  correlation showed that PF was significantly related to PA ( $r=-.207$ ,  $p<.001$ ), F&V ( $r=-.125$ ,  $p<.001$ ), and SE ( $r=-.120$ ,  $p<.01$ ). Multiple regression analysis revealed that PA, F&V, and SE explained almost 15% of the variation of PF in OA. A repeated measures MANCOVA revealed that vigorous PA levels increased in individuals whose PF improved from baseline to 48-months. **Conclusion:** PA, F&V, and SE combined had an additive effect on PF in OA and explained a greater variance in PF than each individual variable. Declines in PA, F&V, and SE did not result in

significant declines in PF in OA; however, results indicate that variable levels at a younger age may be related to PF in OA.

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## **PREFACE**

This thesis is written in the Manuscript Thesis Format as specified on the University of Rhode Island Graduate School website and is prepared for submission to the Journal of the American Geriatrics Society. This thesis contains one manuscript: *The Effect of Physical Activity, Diet, and Self-Efficacy on Physical Function in Older Adults*.

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MANUSCRIPT

**Publication Status**

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## INTRODUCTION

Over the past 55 years, the average life expectancy in the US has increased from 69.8 years to 78.8 years.<sup>1</sup> As life expectancy increases, older adults (OA) are facing challenges not previously experienced by earlier generations, including increased risk and prevalence of chronic diseases, injuries, and disabilities; increased healthcare costs; and decreased quality of life.<sup>2-3</sup> Maintaining high levels of physical function (PF) can play an important role in delaying or preventing these challenges.<sup>4-6</sup>

PF is an all-encompassing term that includes an individual's mobility as well as their capability to perform activities of daily living (ADLs) and instrumental activities of daily living (IADLs).<sup>7</sup> A decline in PF has been associated with increased mortality, rate of hospitalization and injury, and morbidity<sup>4,8</sup>, while improvements in PF have resulted in decreased hospital and nursing home admission and risk of falls<sup>6</sup>.

Physical activity (PA), fruit and vegetable consumption (F&V), and self-efficacy (SE) are related to PF in OA.<sup>9-11</sup> Cross-sectional studies have demonstrated that higher levels of PA and SE have been consistently correlated with higher levels of PF<sup>12</sup>, while F&V consumption has been inversely associated with disability<sup>16</sup> and positively correlated with lower extremity strength.<sup>18-19</sup> Unfortunately, levels of PA and F&V are consistently lower in OA compared to younger populations. Less than 25% of OA are meeting national guidelines for PA<sup>20</sup> of 150 minutes per week of moderate to vigorous PA. The average OA male consumes 1.7 cups of vegetables and 1.4 cups of fruit per day out of the recommended 2.5 to 3.5 and 2.0 to 2.5 cups per

day, respectively. The average OA female consumes 1.5 cups of vegetables and 1.3 cups of fruit per day out of the recommended 2.0 to 3.0 and 1.5 to 2.0 cups per day, respectively.<sup>16</sup> Lower SE is associated with decreased PF in OA.<sup>15,20</sup> SE demonstrates an inverse relationship with aging due to the perception that there is an automatic decline in PF with increasing age.<sup>14,20</sup>

Interventions designed to improve PA, F&V, and SE in OA have resulted in significant improvements in PF. PA specific interventions have resulted in significant improvements in PF.<sup>22</sup> An intervention by Neville et al. designed to increase F&V found non-significant increases in PF<sup>23</sup>; however, when a PA component was added to the F&V intervention there were significant improvements in PF.<sup>24</sup> Similarly, PA interventions that incorporate a SE component resulted in significantly greater improvements in PF in OA compared to interventions that do not include a SE component.<sup>25-26</sup> This may be due to the relationship found between changing PA and SE levels in OA.<sup>27-28</sup>

No research has been identified on the combined effect of PA, F&V, and SE on PF in OA. Therefore, the purpose of this study was threefold to determine: (1) the relationship between physical function and PA levels, F&V intake, and exercise SE; (2) the percentage of variance in PF that is explained by PA levels, F&V, and exercise SE; and (3) how changes in PA, F&V, and SE affect changes in PF in OA. It was hypothesized that PA and exercise SE will have a strong positive association with PF, whereas F&V will have a moderate positive association with PF. It also was hypothesized that the combination of PA, F&V intake and exercise SE would explain a greater percentage of the variance in PF compared to the variance caused by each

factor alone. Finally, it was hypothesized that a decrease in PA, F&V intake, or exercise SE would lead to a decrease in PF.

## METHODOLOGY

This is a secondary data analysis of the Study of Exercise and Nutrition in Older Rhode Islanders (SENIOR) II project. A full description of the study has been previously published.<sup>29</sup> Briefly, SENIOR II was a follow-up intervention to the SENIOR I project, a two year study that included a 12-month intervention and a 24-month follow-up. The intervention was based upon the Transtheoretical Model (TTM) of Health Behavior Change with the goal of increasing PA and F&V consumption in community-dwelling adults aged 60 years and older ( $n = 1277$ )<sup>30</sup>. SENIOR II was initiated three and a half years following the completion of SENIOR I, and recruited subjects from the SENIOR I project who were physically active (exercised for 20 minutes, three times per week), regularly consumed five or more servings of F&V per day, or participated in both behaviors at the 24-month follow-up. The purpose of SENIOR II was to help study participants maintain these healthy behaviors in the face of increasing challenges associated with aging. Participants randomized to intervention arms received manuals, newsletters, and coaching phone calls to encourage them to maintain the healthy behaviors. Data were collected at baseline, 12-, 36-, and 48-months.

### **Measures**

#### ***Physical Activity***

Physical activity was measured using the Yale Physical Activity Survey (YPAS). The YPAS is an interviewer-administered survey developed to assess the PA levels of OA in a typical week within the past month.<sup>31</sup> Participants quantified the

frequency and duration of participation in five activity dimensions: vigorous activity, leisurely walking, moving around on feet, standing, and sitting. Weights were assigned to each dimension. The frequency and duration scores were multiplied together and then multiplied again by each dimension's weighting factor to calculate an index for each dimension. The five individual indices were summed to calculate the summary index.

### ***F&V Consumption***

F&V consumption was measured using the National Cancer Institute Fruit and Vegetable (NCI F&V) Screener. The NCI F&V Screener is a 19-item questionnaire that assesses the number of servings of F&V consumed in an average day over the past month.<sup>32</sup> It includes consumption of whole F&V, as well as servings of F&Vs found in soups and juices.

### ***Exercise Self-efficacy***

The six-item exercise SE scale measured a subject's confidence in his/her ability to exercise despite adverse or challenging situations.<sup>33</sup> Self-efficacy scores range from 1 to 5, with higher scores indicating greater SE.

### ***Physical Function***

Physical function was measured using the Timed Up and Go (TUG) test. The TUG is a practical, reliable measure of functional mobility in older adults.<sup>34</sup> The TUG test measures, in seconds, the time taken by an individual to stand up from a standard chair, walk a distance of three meters, turn, and walk back to the chair and sit down again. The score is recorded in seconds taken to complete the task. TUG scores have been able to distinguish between OA who need assistance in ADLs, those who are

independent, and those with somewhat impaired mobility.<sup>35</sup> TUG scores of less than 14 seconds were found to reflect the ability of OA to function independently in the SENIOR I study, with higher scores reflecting PF limitations in this population.<sup>36</sup>



## STATISTICS

Means and standard deviations for all descriptive variables, as well as baseline correlations between variables, were calculated at baseline using IBM SPSS Statistics v23. F&V intakes as reported by the NCI Fruit and Vegetable Screener were square-root transformed for all analyses. All other statistical analyses included only those individuals who had complete data at baseline and 48-months. The relationship between PF and PA levels, F&V intake, and SE at baseline was examined using Pearson's  $r$  product moment correlations. A multiple regression analysis was conducted to determine the percentage of variance in PF that is explained by PA, F&V, and exercise SE at baseline. To evaluate the change in TUG scores as well as PA, F&V, and SE in relation to a change in PF, subjects were divided into four groups—Independent, Improved, Declined, and Dependent—based upon a TUG cutoff score of 14 seconds (see Table 1). The Independent group consisted of individuals who scored <14 seconds at baseline and 48-months. Improvers consisted of individuals who scored >14 seconds at baseline and <14 seconds at 48-months. Decliners consisted of individuals who scored <14 seconds at baseline and >14 seconds at 48-months. The Dependent group consisted of individuals who scored >14 seconds at baseline and 48-months. A 2 X 4 repeated measures ANOVA with a Bonferroni's post hoc analysis was used to evaluate TUG scores among groups from baseline to 48 months. A repeated measures MANCOVA (controlling for age) was used to examine changes in PA, F&V consumption, and SE based upon group classification. A one-way ANOVA was used to determine significant differences

between baseline and 48-month means between TUG groups for each outcome measure. Statistical analysis is set at an alpha level of  $p < .05$  for all tests of statistical significance.

## RESULTS

A total of 470 participants were recruited for SENIOR II. A total of 470 subjects were included in the study. The majority of the participants were Caucasian (79.8%), female (74.9%), and overweight (38.9%) (Table 1). The mean age of participants at baseline was 79.9 (SD 5.7). Table 2 shows baseline scores for TUG, YPAS summary index, F&V intake and SE. At baseline, the mean TUG score was  $12.09 \pm 7.79$ , indicating independent function according to the classification by Garber et al.<sup>36</sup>

Results of Pearson  $r$  correlations that were calculated to investigate the relationship between baseline PF, PA, F&V, and exercise SE revealed significant relationships at baseline between Yale Summary Index ( $r = -.21$ ,  $p < .001$ ), F&V consumption ( $r = -.11$ ,  $p < .01$ ), and SE ( $r = -.12$ ,  $p < .01$ ) and TUG scores (see Table 3). Of the five YPAS Summary Index components, moving around ( $r = -.24$ ,  $p < .001$ ), followed by sitting ( $r = .24$ ,  $p < .001$ ) and vigorous activity ( $r = -.24$ ,  $p < .001$ ) had the strongest correlation with TUG scores, indicating that those who spent more time moving around on their feet while doing different daily tasks, participated in vigorous PA, and spent less time sitting had better PF based upon a lower TUG score. Significant correlations were found between F&V intake ( $r = -.11$ ,  $p < .01$ ) and fruit intake alone ( $r = -.11$ ,  $p < .01$ ) with TUG scores, and no significant correlation was found between vegetable intake alone ( $r = -.06$ ,  $p > .05$ ) and TUG scores. These results indicate there is a significant, relationship between PA, F&V consumption, and SE and PF in OA.

To look at the independent effects of PA, F&V, and exercise SE on PF, a series of hierarchical regression models were constructed to examine the unique contribution of these variables on TUG scores (see Table 4). PA ( $r^2=.121$ ) significantly contributed to the percent of variance of TUG scores, with PA, F&V, and SE combined explaining almost 15% of the variance ( $r^2=.146$ ,  $p<.001$ ). Specifically, increased vigorous PA ( $\beta=-.161$ ) and decreased sitting time ( $\beta=.172$ ) were the most predictive higher PF levels. Only a small proportion of variance ( $r^2=.020$ ) is attributed to the combination of PA and F&V consumption.

Unadjusted paired sample t tests were performed to determine if there was a significant change in PA, F&V, and SE between baseline and 48-months. Significant increases were found for the TUG [ $t(237)=-4.166$ ,  $p<.05$ ], sitting [ $t(237)=-8.180$ ,  $p<.05$ ], and vegetable consumption [ $t(237)=-2.267$ ,  $p<.05$ ]. Significant decreases were found for the Yale Summary Index [ $t(237)=4.326$ ,  $p<.05$ ], standing [ $t(237)=4.387$ ,  $p<.05$ ], moving [ $t(237)=2.217$ ,  $p<.05$ ], vigorous activity [ $t(237)=5.678$ ,  $p<.05$ ], fruit consumption [ $t(237)=3.306$ ,  $p<.05$ ], and self-efficacy [ $t(237)=3.755$ ,  $p<.05$ ]. No significant changes were found for walking [ $t(237)=1.034$ ,  $p>.05$ ] or F&V consumption [ $t(237)=.368$ ,  $p>.05$ ] (Table 5).

A 2 x 4 ANOVA with repeated measures with post hoc analysis revealed a significant main effect for time and group. The Independent group had significantly lower TUG scores at baseline and 48 months compared to the other three groups (Improved, Declined, and Dependent). In the Improved group TUG scores increased from baseline to 48 months while the other three groups' TUG scores decreased from baseline to 48 months. There was a significant time x group interaction effect ( $\lambda=.755$ ,

$F=28.386, p<.001$ ) for change in TUG scores. The Independent group had a significantly smaller decrease in TUG scores compared to the TUG scores for the Declined and Dependent groups. At baseline and 48-months, the Independent group had significantly lower TUG scores compared to the remaining three groups, with the Dependent group having significantly higher TUG scores than the remaining three at 48-months.

Results of the repeated measures MANCOVA determined that there was a significant multivariate time x TUG group interaction ( $\lambda=.853, F=1.546, p<.05$ ), and within-subject univariate tests revealed a significant effect of time x TUG group for F&V ( $p<.05$ ) (Table 7).

To determine any significant differences in baseline means of PA, F&V, and SE between groups, a one-way ANOVA was conducted. Significant differences were found among groups for baseline vigorous activity [ $F(3, 234)=4.874, p<.01$ ], moving [ $F(3, 234)=4.819, p<.01$ ], standing [ $F(3, 234)=7.357, p<.001$ ], sitting [ $F(3, 234)=2.870, p<.05$ ], YPAS Summary Index [ $F(3, 234)=5.370, p<.01$ ], and SE [ $F(3, 234)=4.445, p<.01$ ] (Table 7). A post hoc analysis with Bonferroni's correction found that the Independent group had significantly higher baseline scores for Yale Summary Index, vigorous activity, moving around, standing, and SE than the Dependent group, and had significantly higher scores for standing compared to the Declined group. The Improved group had significantly higher standing scores than the Declined group.

## DISCUSSION

This study found a significant positive relationship between PA, F&V, and SE and PF in OA. PA, F&V, and SE together explained almost 15% of the variance in PF in this population. Subjects who improved their TUG scores significantly increased their vigorous PA compared to subjects who remained dependent at baseline and 48-months, and individuals who maintained independence had a significantly smaller decrease in SE than those who declined PF.

PA had a significant positive correlation with PF in OA. It was hypothesized that both PA and SE would demonstrate a strong correlation with PF. However, our results show a weak correlation ( $r < .30$ ) between these variables. The results of the current study are consistent a previous study that found a weak correlation ( $r = -.166$ ) between PA and PF in a similar cohort.<sup>13</sup> Of the five tasks represented in the YPAS Summary Index, moving around ( $r = -.24, p < .001$ ), vigorous activity ( $r = -.24, p < .001$ ), and sitting ( $r = .24, p < .001$ ) had the strongest correlations with TUG time, which is consistent with a previous study that found that increased vigorous PA and decreased sedentary time were correlated with improved PF.<sup>12</sup> Significant moderate correlations between vigorous activity ( $r = .523, p < .001$ ) and sedentary time ( $r = -.499, p < .001$ ) and lower extremity function have previously been found by Davis et al.<sup>37</sup> Differences between the strengths of those correlations with those found in the present study may be due to the use of accelerometry to objectively measure of PA and sedentary time by Davis et al. (2014) compared to the use of subjective measures of PA and sedentary time used in the present study, which have an inherent risk of subjective bias. Walking was the

only component of PA that did not demonstrate a significant correlation with the TUG, which is consistent with a previous study that found a moderate but insignificant correlation ( $r=-.55$ ) between total time walking and TUG scores.<sup>38</sup> These results indicate that those who had higher PF spent more time moving around and performing vigorous PA, and less time sitting.

SE demonstrated a significant positive relationship with PF, a finding supported by other studies.<sup>9,27,39</sup> The present study found a weak correlation ( $r=-.150$ ,  $p<.01$ ) between SE and PF. This is in contrast to McAuley et al. (2006) who found a moderate correlation ( $r=-.34$ ,  $p<.01$ ) between exercise SE and PF as measured by the 8 Foot Up and Go.<sup>9</sup> However, the study by McAuley et al. utilized a younger cohort ( $M=68.1$  years,  $SD=6.1$ ) compared to the present study ( $M=79.2$ ,  $SD=5.8$ ), suggesting that SE may play less of a role in PF in OA with increasing age.

F&V demonstrated a weak but significant, correlation ( $r=-.125$ ,  $p<.01$ ) with TUG scores. Fruits alone had a significant correlation with TUG ( $r=-.100$ ,  $p<.01$ ), whereas vegetables did not demonstrate a significant correlation with TUG ( $r=-.084$ ,  $p>.05$ ). This supports the results of a previous study that found that OA who met the recommended servings of F&V had significantly lower odds of developing disability relating to IADLs, with fruit providing additional protection against developing lower extremity mobility and general disabilities.<sup>17</sup> No studies were found that analyzed the correlation between fruit and/or vegetable intake with PF in OA. However, correlational studies have been conducted using levels of micronutrients found in fruits vegetables. Vitamin C, vitamin E, beta carotene, and retinol were found to be

significantly correlated with physical function in older adults.<sup>40-41</sup> The results of both studies indicate a weak correlation similar to that found in the present study.

The present study found that PA, F&V, and SE combined explained 14.6% of the variance in PF as measured by the TUG. PA alone explained 12.1% of the variance in PF. A previous study found that PA explained 19% of the variance in PF as measured by the Short Performance Physical Battery (SPPB).<sup>42</sup> The higher percentage of explained variance may be due to differences in the PF measures—the SPPB includes measures of upper extremity strength and flexibility of both the upper and lower extremities in addition to a chair rise and walking tasks. F&V alone explained .5% of the variance of PF in the present study. The combination of PA, F&V, and SE explained an additional 2.5%. The percent of variance of PF explained by PA and SE have been explored previously in the literature; however, this is the first study found to the percent of variance of PF explained by F&V independently or a combination of PA, F&V, and SE.

SE alone was found to explain no percent of variance of PF in the present study. This is in stark contrast to previous studies that found SE significantly contributed to percent of variance of PF in OA in models including being male and younger ( $R^2=.44$ ) and PA ( $R^2=.47$ ).<sup>9,39</sup> Both studies used younger cohorts with a mean age of 69.4 (58-84)<sup>39</sup> and 68.12 (59-84)<sup>9</sup> compared to the present study. Additionally, the present study used an exercise SE questionnaire related to barriers to PA instead of a task specific SE questionnaire. These findings confirm the results of the Pearson's  $r$  correlation that, with increasing age, SE plays less of a role in modulating PF in OA, especially compared to the role of PA.



When examining all subjects, there were significant increases in TUG scores, sitting time, and vegetable intake, and significant decreases in overall PA, vigorous activity, moving around, standing, fruit intake, and SE from baseline to 48-months. These changes were expected since previous studies have found significant correlations between increasing age and decreasing PF<sup>43</sup>, declining PA levels<sup>44</sup>, and lower SE.<sup>14</sup>

To more closely examine how PA, F&V, and SE affected changes in PF, subjects were categorized into four groups based upon TUG scores at baseline and 48-months. There was a significant time x group effect for change in F&V consumption, with the Dependent group significantly increasing their F&V consumption. Since this group did not improve PF, our results support the findings of Neville et al. (2013) who found that increases in F&V to  $\geq 5$  servings per day did not result in significant improvements in PF in OA between the ages of 65 and 85.<sup>23</sup> There were no significant time x group effect for change in PA and SE, which is in contrast to interventional studies that found significant improvements in PF resulting from improvements in PA alone<sup>45-46</sup> and PA and SE combined<sup>25,46</sup> in subjects with a similar age range to the present study. Our results indicate that improvements or declines in PA, F&V, and SE are not associated with changes in PF in community dwelling OA between the ages of 67 and 99.

There were significant differences between baseline means among TUG groups for all variables except walking and F&V. The Independent group had significantly higher baseline Yale Summary Index, vigorous activity, moving around, standing, and SE scores than the Dependent group. Compared to the Declined group, the

Independent group had significantly higher standing scores. Between baseline and 48-month TUG scores, the Independent group maintained the lowest TUG scores when comparing all four groups, regardless of the significant decrease in Independent TUG scores from baseline to 48-months. These findings suggest that levels of PA, SE, and sedentary behavior at a younger age are more predictive of PF in OA than changes in these variables over time. Studies have previously demonstrated that higher baseline PA and SE levels are associated with higher levels of PF in OA.<sup>43,47-49</sup>

This is the first study to demonstrate a significant correlation between F&V and PF and determine the percent of variance in TUG scores that is explained by F&V. All three independent variables demonstrated significant correlations with PF as measured by the TUG; however, only PA and F&V explained variance in PF, with PA accounting for the greatest percent of variance. There were no significant changes in PA, F&V, or SE that affected an improvement or decline in PF. Baseline values of vigorous PA, sitting time, and SE were higher for the Independent group compared to the other three groups, suggesting that baseline PA and SE may be associated with PF levels after a 4 year interval, with individuals who maintained independence having higher baseline values compared to the remaining individuals. These results suggest that while PA, F&V, and SE are significantly correlated with PF, it is not the change in these variables but the baseline values that are predictive of PF in OA. These results suggest that improving levels of PA and SE in individuals prior to older adulthood may delay or slow the age-related decline in PF.

This study had many strengths and limitations. Among the strengths, this study utilized data from a large cohort ( $N=470$ ) of community dwelling OA over a period of

four years, allowing the researchers to assess changes in PA, F&V, SE, and PF with increasing age. By using this subject population, the relationship between changes in PA, F&V, and SE and changes in PF during the normal aging process can be assessed. The SENIOR studies had limited exclusion criteria, allowing for recruitment of individuals with a variety of diagnoses and functional statuses, allowing for generalizability of the results from the present study to the general population of OA within the US. No other studies were found that assessed the influence of all three correlates with PF in OA, nor the percent of variance of F&V consumption on PF in OA.

Limitations of the study include a small fraction of subjects who improved physical function ( $N=11$ ) compared to the other three groups. As well, the measures for PA and F&V were self-reported, which could lead to misrepresentation of actual PA and F&V levels in OA. While the use of community-dwelling independent OA is a strength of the study, it is also a limitation as the results may not be generalizable to all other OA. Additionally, the analyses including baseline and 48-month data only includes those subjects who survived to the 48-month data collection. Future studies should include objective measures of PA and F&V to provide accurate representations of levels of and changes in PA and F&V in OA.

In conclusion, PA, F&V, and SE are significantly correlated with PF as measured by the TUG in OA. Declines or improvements in PA, F&V, or SE did not result in respective declines or improvements in PF in OA. For the Independent group, baseline standing and SE scores were significantly higher than the Declined and Dependent groups, and baseline Yale Summary Index, vigorous activity, and moving around

scores were significantly higher than the Dependent group only. These results suggest that higher baseline PA and SE levels may play a role in predicting changes in PF with increasing age and demonstrates a need for further study on the relationship between PA and SE in young adults with PF as they age.

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## APPENDICES

### TABLES

Table 1: Timed Up and Go (TUG) Group Criteria

Group	Baseline TUG Score	48-Month TUG Score
Independent	<14 seconds	<14 seconds
Improved	$\geq$ 14 seconds	<14 seconds
Declined	<14 seconds	$\geq$ 14 seconds
Dependent	$\geq$ 14 seconds	$\geq$ 14 seconds

Table 2: Subject Demographics

	N	%
<b>Gender</b>		
Female	352	74.90
Male	118	25.10
<b>Age</b>		
65-69	6	1.30
70-74	71	17.20
75-79	146	31.10
80-84	140	29.80
85-89	72	15.30
90-94	18	3.80
95-99	7	1.50
Mean	79.9	
SD	5.8	
<b>Ethnicity</b>		
Caucasian	368	79.80
African-American	10	2.20
Asian-Pacific Islander	1	0.20
American Indian/Alaskan	3	0.70
Hispanic	2	0.40
Portuguese	40	8.50
Cape Verdean	17	3.60
Other	20	4.20
<b>BMI</b>		
Underweight (<18.5)	3	0.60
Normal (18.5-24.9)	126	26.80
Overweight (25.0-29.9)	183	38.90
Obese (>30)	158	33.60

Table 3: Baseline Values for PA, F&V, SE, PF

	N	Mean	SD
Yale Summary Index	465	37.59	22.61
Vigorous Activity	465	12.32	17.71
Leisurely Walking	465	10.47	11.75
Moving Around	465	8.70	3.11
Standing	465	4.02	2.01
Sitting	465	2.08	.75
Fruit and Vegetables	457	7.17	3.47
Fruits	463	3.89	2.31
Vegetables	462	3.28	2.21
Self-Efficacy	470	4.13	1.27
Timed Up and Go	453	12.09	7.79

PA: Physical Activity; F&V: Fruit and vegetables; SE: self-efficacy; PF: physical function

Table 4: Baseline Correlations between PF, PA, F&amp;V, SE (N = 437)

Outcome	TUG	Yale Sum	Sitting	Standing	Moving	Walking	Vig. Act.	F&V	Fruit	Vegetable	SE
TUG	--	-.21**	.24**	-.21**	-.24**	.05	-.24**	-.11*	-.11*	-.06	-.12*
Yale Sum		--	-.15**	.31**	.37**	.54**	.83**	.16**	.09	.15**	.42**
Sitting			--	-.13**	-.19**	-.02	-.17**	-.08	-.04	-.09	-.11*
Standing				--	.40**	.07	.18**	.17**	.18**	.08	.16**
Moving					--	.09	.21**	.14**	.05	.16**	.17**
Walking						--	.01	.02	.06	-.03	.19**
Vig. Act.							--	.15**	.04	.17**	.37**
F&V								--	.74**	.78**	.19**
Fruit									--	.14**	.15**
Vegetable										--	.14**
SE											--

\*p&lt;.01

\*\*p&lt;.001

PF: physical function; PA: physical activity; F&V: fruit and vegetable; SE: self-efficacy; TUG: Timed Up and Go; Vig. Act.: Vigorous Activity

Table 5: Hierarchal Regression of PA, F&V, and SE on PF at Baseline (N = 436)

Predictors	$\beta$	$R^2$	F	$p$
Physical Activity		.121	12.137	.000
Sitting	.172			.000
Standing	-.100			.046
Moving	-.141			.006
Walking	.080			.082
Vigorous Activity	-.161			.001
Fruits and Vegetables		.005	1.358	.258
Fruits	-.076			.101
Vegetables	.015			.740
Self-Efficacy	-.010	.000	.042	.837
Combined		.146		.000

PA: physical activity; F&V: fruit and vegetable; SE: self-efficacy; PF: physical function



Table 6: Baseline and 48-month Outcome Measure Scores (N = 238)

	Baseline		48 Months	
	Mean	SD	Mean	SD
TUG*	10.24	3.67	12.23	8.56
		23.4		
Yale Summary Index*	40.23	5	32.93	22.34
Sitting*	2.04	.70	2.52	.81
Standing*	4.23	1.93	3.62	1.51
Moving*	9.09	3.10	8.62	2.66
		11.0		
Walking	10.42	8	10.86	12.42
		18.8		
Vigorous Activity*	14.45	5	7.31	14.31
Fruit & Vegetable	7.45	3.53	7.41	2.98
Fruit*	3.42	2.17	2.96	1.50
Vegetable*	4.03	2.39	4.44	2.23
Exercise Self-Efficacy*	4.25	1.21	3.86	1.55

\*t test significance,  $p < .05$

Table 7: Baseline and 48-Month TUG Scores By Group

	Baseline		48-Month	
	Mean	SD	Mean	SD
Independent <sup>b, c, d</sup>	8.96	1.66	9.50	2.09
Improved <sup>a, f</sup>	18.64	3.42	11.39	1.71
Declined <sup>b, e</sup>	10.56	1.58	18.39	4.64
Dependent <sup>b, f</sup>	17.66	4.13	26.39	18.33

a: Decreased TUG from baseline to 48-months

b: Increased TUG from baseline to 48-months

c: Lower baseline TUG scores than Improved, Declined and Dependent

d: Lower 48-month TUG scores than Improved, Declined, Dependent

e: Increased TUG time from baseline to 48-months compared to Independent

f: Increased TUG time from baseline to

48-months compared to Independent and Declined

P < 0.05

Table 8: Changes Between Baseline and 48-month Outcome Measures By Group

Outcome	Group	N	Baseline	48 Months	Time	Time x Group
Yale Summary Index	Improved	6	40.3±36.1	37.5±30.2	.211	.089
	Independent <sup>a</sup>	182	42.9±23.0	33.0±21.2		
	Dependent	23	22.9±13.9	21.0±16.4		
	Declined	27	37.2±24.6	41.4±28.3		
Vig. Act.	Improved	6	17.5±26.0	16.7±26.6	.072	.135
	Independent <sup>a</sup>	182	16.5±19.3	7.4±14.1		
	Dependent	23	1.5±4.6	1.1±4.3		
	Declined	27	11.1±17.2	10.0±16.7		
Walking	Improved	6	8.0±9.1	5.3±8.3	.742	.192
	Independent	182	10.5±10.6	10.5±11.7		
	Dependent	23	9.4±12.6	7.5±12.7		
	Declined	27	11.4±13.5	17.5±15.7		
Moving	Improved	6	7.0±4.1	8.5±4.0	.339	.504
	Independent <sup>a</sup>	182	9.5±3.1	9.0±2.5		
	Dependent	23	7.3±2.5	6.8±2.4		
	Declined	27	8.6±3.0	7.9±2.7		
Standing	Improved <sup>c</sup>	6	5.3±2.4	4.3±2.0	.676	.560
	Independent <sup>a, b</sup>	182	4.5±1.9	3.8±1.4		
	Dependent	23	2.7±1.4	2.7±1.4		
	Declined	27	3.8±1.7	3.1±1.6		
Sitting	Improved	6	2.5±1.0	2.7±1.0	.925	.088
	Independent	182	2.0±.7	2.4±.7		
	Dependent	23	2.0±.6	2.9±1.0		
	Declined	27	2.3±.8	2.9±.9		
F&V	Improved	6	6.9±2.4	7.4±2.0	.691	.026
	Independent	182	7.7±3.8	7.3±3.0		
	Dependent	23	6.4±1.8	7.4±2.0		
	Declined	27	6.6±2.4	7.4±2.4		
Fruit	Improved	6	3.3±1.4	2.4±1.8	.761	.068
	Independent	182	3.6±2.4	3.0±1.6		
	Dependent	23	2.8±1.0	3.0±1.0		
	Declined	27	2.6±1.2	2.9±1.2		
Vegetable	Improved	6	3.6±1.5	5.0±1.5	.767	.101
	Independent	182	4.1±2.6	4.3±2.2		
	Dependent	23	3.6±1.4	5.3±2.8		
	Declined	27	4.0±1.7	4.5±1.7		
SE	Improved	6	3.7±1.4	2.8±1.8	.120	.061
	Independent <sup>a</sup>	182	4.4±1.1	4.1±1.5		
	Dependent	23	3.6±1.3	2.9±1.6		
	Declined	27	4.0±1.3	3.0±1.4		

a: Independent significantly higher than Dependent at baseline

b: Independent significantly higher than Declined at baseline

c: Improved significantly higher than Dependent at baseline

## REVIEW OF LITERATURE

### **OLDER ADULTS**

Older adults (OA) currently make up 14.1% of the U.S. population and are expected to grow to 21.7% of the population by the year 2040.<sup>1</sup> The current life expectancy for individuals aged 65 years within the U.S. is 19.2 years, which is five years older than OA in 1960.<sup>2</sup> With this increased life expectancy comes challenges not previously experienced by earlier generations, including an increased risk and prevalence of chronic diseases, injuries, and disabilities, increased health care costs, and a decreased quality of life.<sup>3,4</sup> Disability affects 49.8% of OA, compared to 18.7% of the entire population (including those 65 and older).<sup>5</sup>

### **Physical Function in Older Adults**

Disability, according to Nagi's Disability Model, is defined as (a) limitation(s) in performing activities required for an individual's role in society--including self and home care, work, and community participation.<sup>6</sup> Disability includes limitations or impairments related to mobility and independence with activities of daily living (ADLs; basic self-care activities, including bathing and eating) and instrumental activities of daily living (IADLs; activities required for independent living within the community, including grocery shopping, and driving).<sup>3,4</sup> Individuals with disability demonstrate a lower life expectancy<sup>4,7</sup>, decreased quality of life<sup>8</sup>, increased risk of hospitalization<sup>9-10</sup>, increased health care costs<sup>10</sup>, and decreased independence.<sup>10</sup> Physical function (PF) is a precipitator of<sup>6</sup> and is highly correlated with disability<sup>11</sup> and successful aging.<sup>12</sup>

Functional limitations are impairments at a performance level<sup>6</sup> that would include such things as impaired gait or decreased independence with transfers. A decline in PF has been associated with increased mortality<sup>13</sup>, rate of hospitalization and injury<sup>14</sup>, falls<sup>15</sup>, and a decline in cognitive function.<sup>16</sup> In a longitudinal study, Dapp, Minder, Anders, Golgert, & von Renteln-Kruse (2014) found that functional ability predicted mortality and that the need for nursing care was independent of age and gender.<sup>17</sup> Improvements in PF result in decreased hospital and nursing home admission and risk of falls.<sup>18</sup>

There is a current trend towards the reduction of disability by 1.0% to 2.5% each year within the U.S.<sup>3</sup>; however, this still leaves millions of OA with disabilities. To further decrease disability prevalence among OA, the correlates of PF need to be identified. Once these correlates have been identified, evidence based interventions can be developed and implemented to improve PF, and ultimately disability rates, in OA. Three correlates that have been studied most frequently in the literature are physical activity (PA), diet, and self-efficacy (SE). This review of literature will present the status of these correlates within the OA population, the relationship of these correlates with PF, and the effects of interventions designed to improve upon these correlates.

### **Measuring Physical Function in Older Adults**

To assess a change in PF in OA, it is important to utilize a reliable and valid measure that has established normative data and is sensitive to clinically significant changes for this population. The Timed Up and Go (TUG) test is one such measure.<sup>19-</sup>  
<sup>22</sup> Originally developed to assess disability in frail OA, this measure has been found to

predict future ADL and IADL disability<sup>19</sup>, falls<sup>22</sup>, and mortality in community dwelling OA.<sup>23-24</sup>

Equipment required for this test includes a stopwatch and a chair without armrests that allows the participant to sit with hips and knees in 90 degrees of flexion. The participant is asked to stand up from the chair without the use of his or her upper extremities, ambulate 3 meters, navigate around a cone, ambulate back to the chair, and return to a seated position, once again without the use of upper extremities. The tester begins the stopwatch when he or she gives the command 'Go'. The score is the time, in seconds, for the participant to complete the task. Lower scores are associated with higher physical function, and higher scores are associated with lower physical function.

## **PHYSICAL ACTIVITY**

### **Physical Activity Levels in Older Adults**

With increasing age, there is a trend towards decreased PA and increased sedentary time.<sup>25-29</sup> Compared to younger populations, OA spend a significantly less amount of time performing moderate to vigorous PA<sup>30</sup> and overall PA.<sup>27-28</sup> The current guidelines recommend that adults acquire 150 minutes per week of moderate intensity PA or 75 minutes per week of vigorous PA.<sup>31-32</sup> In 2010, only 14% of those aged 65 to 74 and 4% of those aged 85 and older met the recommended PA guidelines.<sup>2</sup> One-half to two-thirds of OA are physically inactive.<sup>29,33</sup> PA levels in OA are lowest among those who are female, older, smokers, obese, of Hispanic or African American descent, with lower education, and have a chronic illness.<sup>26,29</sup>

The form and intensity of PA performed changes with age, as demonstrated by the prevalence of running, team sports, weightlifting, and aerobics in younger adults compared to OA, who in turn demonstrate a greater prevalence of walking, yardwork and gardening, golf, and bicycling, with walking, bicycling, and gardening accounting for over 75% of the PA performed by PA.<sup>29</sup> These trends reflect a transition from moderate to vigorous PA performed in younger adults to light to moderate intensity PA as adults age.<sup>29</sup> This transition to lower PA intensity with increasing age is often due to lack of time, fear of falling or injury, physiological impairments, and lack or resources, with the latter three specific to OA.<sup>34-35</sup>

### **Physical Activity and Physical Function**

Consequences of decreased PA are decreased aerobic endurance, muscular strength, and balance, as demonstrated by the positive relationship between PA and these physiological measures of fitness in OA.<sup>36-38</sup> Sarcopenia, a reduction in muscle mass and strength due to aging, affects 7% to 50% of the population  $\geq 65$  years of age and increases the risk of disability by 79%.<sup>39</sup> PA has been shown to reduce or prevent the loss of strength associated with sarcopenia.<sup>36,40</sup> Strength, balance, and aerobic endurance are required to safely and independently perform activities of daily living (ADLs)<sup>36</sup>, which is a component of physical function (PF); thus, it is reasonable to explore the direct relationship between PA and PF.

PA positively correlates with an individual's level of PF and negatively correlates with an individual's level of disability.<sup>33,41-44</sup> This relationship is independent of body mass index (BMI) or weight<sup>33,42,45</sup>, with research showing that physically active overweight or obese individuals have higher levels of PF and



decreased disability compared to their normal weight, sedentary peers. However, one study found that PA preserves PF in obese males but not females.<sup>46</sup> This relationship remains significant when accounting for covariates, such as age, gender, education, and smoking<sup>42</sup>, indicating that PA may be more predictive of PF than those covariates. When defining PA as steps taken per day (including steps during leisurely activity instead of structured exercise), higher step counts were positively correlated with PF, indicating the benefit of total daily activity on PF.<sup>47</sup>

Researchers also have assessed the relationship between the time spent in sedentary behavior with physiological variables and PF.<sup>41,48-51</sup> Studies indicate that sedentary time is negatively correlated with PF and/or disability in OA.<sup>41,52</sup> Increased sedentary time has been linked to decreased grip strength<sup>48</sup>, gait speed<sup>52-53</sup>, and balance<sup>48</sup>. Conversely, one study found sedentary time is not predictive of a decline in PF in OA<sup>54</sup>, with another study demonstrating no significant correlation between sedentary behavior and hand grip strength, postural stability, or fall risk in OA.<sup>55</sup>

### **Type and Amount of Physical Activity**

While there is an overwhelming consensus on the protective effect of PA on maintaining function and various physiological variables in the literature, there remains a lack of consensus regarding the intensity of PA and time spent being physically active necessary to significantly affect PF in OA. Significant positive correlations have been found between moderate to vigorous levels of PA (MVPA) and PF outcome measures.<sup>41,48</sup> One study found that subjects who participated in light (N=17, mean age 70.3±5.7) and vigorous PA (N=17, mean age 69.8±4.4) improved overall balance, only vigorous PA significantly improved dynamic balance as

demonstrated by gait and sit to stand movements.<sup>56</sup> Other cross-sectional studies indicate that light PA is as beneficial as MVPA to preserve PF<sup>48-49,54</sup>, with two studies indicating no statistically significant difference in PF between groups who performed different intensities of objectively and subjectively reported PA.<sup>49,57</sup>

The relationship between the time spent being physically active and PF has also been investigated. Studies suggest that greater total time spent performing PA correlates with higher levels of PF.<sup>48-49,57</sup> Adults who meet the PA recommendations have higher functional scores than their peers who do not meet the recommended PA levels.<sup>41,58-59</sup> Dropping below the recommended PA threshold results in a clinically significant decline in PF.<sup>59</sup> In contrast, two studies found a strong positive relationship between regular PA and PF even in individuals who did not meet national PA guidelines<sup>44,60</sup>, with an increase of 10 minutes/day of even low intensity PA resulting in a significant improvement in PF.<sup>60</sup> Gebel et al. (2014) found that, independent of total MVPA, a 1% increase in total time spent being physically active resulted in 0.3% decreased risk of a decline in PF.<sup>58</sup>

Nonetheless, it remains unclear, if PA initiated later in life is as protective of PF in OA as PA levels in adults <65 years of age. Following a 9-month PA intervention, OA between 65-74 years of age were able to maintain significant improvements in PF, whereas OA 75 years of age and older did not maintain significant improvements in PF.<sup>61</sup> Stenholm et al. (2015) found that individuals with a higher level of PA in early adulthood and late midlife had a smaller decline in PF compared to individuals with lower levels of PA in early adulthood.<sup>62</sup> These results support the findings by Manini and Pahor (2009) that PA early in life is more

predictive of PF in the aging population.<sup>43</sup> However, interventions to increase PA in OA who are sedentary have been successful in improving PF<sup>38</sup>, indicating that PA performed later in life also will preserve PF.

### **Interventions to Increase Physical Activity and Physical Function**

Many studies have measured the effects of interventions designed to increase PA levels in OA with the goal of improving physiological variables related to and overall PF.<sup>38,61,63-66</sup> Cardiovascular exercise, flexibility and balance training, and resistance exercise interventions have resulted in increased lower extremity strength in OA.<sup>63,65-66</sup>

Multi-component interventions have been created, which integrate flexibility, strengthening, and cardiovascular exercises.<sup>38,61,64,67-68</sup> Results from these studies indicate that these interventions can result in an improvement in multiple physiological variables, such as arm strength<sup>67</sup>, grip strength<sup>61,67</sup>, lower extremity strength<sup>68</sup>, flexibility<sup>61</sup>, and balance.<sup>38,61,68</sup> However, Nelson et al. (2004) found no significant differences between an exercise (N=34, mean age=77.7±5.3) and control group (N=38, mean age=77.8±5.3) in strength and aerobic endurance following a 6-month exercise intervention for OA.<sup>38</sup> This may be due to the fact that Nelson et al. implemented a home-based exercise intervention versus a laboratory or center based exercise intervention as implemented in other studies.<sup>61,67-8</sup> A systematic review of exercise intervention studies to improve balance in OA demonstrated mixed results.<sup>69</sup> The lack of consensus among the studies cited could be secondary to poor adherence and different exercise protocols, both of which were not adequately described in all studies included in the review.

PA interventions have been successful in improving PF in OA<sup>38,64,67-68</sup>, with differences found between individuals aged 64 to 74 years and 75 and older in changes in strength.<sup>61</sup> Ip et al. (2013) demonstrated that OA between the ages of 70 and 89 who participated in a PA program decreased the odds of experiencing a decline in PF by 60%.<sup>64</sup> However, 56% of individuals participating in both the PA and successful aging groups did not experience any change in PF from baseline to 12 months, demonstrating the variability of response to a PA intervention and the possibility of additional correlates of PF not addressed by the intervention.

PA interventions have been implemented in unhealthy OA, including those classified as having dementia<sup>70</sup> or frail.<sup>71</sup> In OA with dementia, PA interventions have been found to increase static and dynamic balance<sup>70</sup>, but only static balance in frail OA.<sup>71</sup> In frail OA, exercise was found to improve gait speed, but not Timed Up and Go scores<sup>71-72</sup>, and to have mixed results on ADL performance.<sup>72</sup> One study found that not all participants improved in PF following an exercise intervention, with some participants actually demonstrating a decrease in PF.<sup>73</sup> Following two PA interventions, it was found that PA decreased the risk of moving to a lower state of PF by 60%.<sup>64</sup>

PF has been strongly correlated with physiological variables, such as strength, balance, and endurance, as well as PF in a variety of OA subpopulations. Consequently, there have been many exercise interventions implemented to preserve or improve PF in this population. Among those studies, however, lies a lack of consensus regarding the benefits of a PA intervention. This is due to differences in participant characteristics, the number of participants, the duration of the intervention,

and the design of the intervention. Further studies need to be conducted to analyze the effects of PA on the PF and physiological variables required for OA to carry out ADLs.

## **DIET**

### **Diet of Older Adults**

The overall American diet quality does not meet the recommendations set forth in the Dietary Guidelines for Americans.<sup>74</sup> OA have been found to have an especially poor diet quality. A retrospective study of previously published data found 46.2% of subjects were at risk for malnutrition and 22.8% of subjects were classified as malnourished.<sup>75</sup> Malnourishment is characterized by an inadequate intake of calories, macronutrients, and micronutrients. This is caused by a trend towards consuming fewer calories, and thus insufficient amounts of minerals, vitamins, and protein in OA, with older men and women consuming as much as 1,200 kcal/day or 800 kcal/day less than younger men and women, respectively.<sup>76</sup> Specific micronutrients that have identified as inadequately consumed in OA's diets are vitamins A, B6, C, and D, calcium, magnesium, fiber, zinc, and folate.<sup>77</sup> Overweight and obese OA are also at risk of malnutrition, with diets high in empty calories and low in nutrient content and density.<sup>78</sup> As of 2012, OA did not meet the recommended guidelines for consumption of specific food groups, including fruit, dark green and orange vegetables and legumes, and whole grains<sup>2</sup> and exceeded the recommended guidelines for salt, alcohol, and saturated fat intake.<sup>2,77</sup>

One important component of the Dietary Guidelines for Americans is the consumption of five or more servings of F&V per day. Currently, less than half of the

population over 65 years of age meets the recommended five or more servings of F&V per day.<sup>79</sup> According to the USDA's Dietary Guidelines 2015-2020, the average OA male consumes 1.7 cups of vegetables (of the recommended 2.5 to 3.5) and 1.4 cups of fruit (of the recommended 2.0 to 2.5) per day, and the average OA female consumes 1.5 cups of vegetables (of the recommended 2.0 to 3.0) and 1.3 cups of fruit (of the recommended 1.5 to 2.0) per day.<sup>74</sup> Barriers to meeting the recommended daily servings of F&V include health conditions that limit an OA's ability to go to the grocery store or prepare F&V, decreased appetite, decreased social support and interaction, and socioeconomic status.<sup>80</sup>

### **Relationship between Fruit and Vegetable Consumption and Physical Function**

Poor diet quality is linked to multiple diseases in OAs, including cardiovascular disease, Type 2 Diabetes, and various cancers.<sup>2</sup> These chronic diseases are often responsible for an individual's decline in PF and independence and have an increased prevalence in the OA population compared to a younger population.<sup>81</sup> Specifically, inadequate consumption of F&V has been linked to impairments related to mobility IADLs, and ADLs<sup>82</sup>, as well as osteoporosis, cardiovascular disease, some forms of cancer, and overall mortality.<sup>80</sup> Individuals with the highest F&V consumption display successful aging--defined as living to the age of 70 or older without functional limitations or major chronic diseases.<sup>83</sup>

F&V consumption demonstrates a positive relationship with PF<sup>80,82,84-85</sup>, with increased F&V consumption associated with reduced frailty and walking impairments<sup>80</sup> and improved PF.<sup>85</sup> These relationships are supported by the work of Xu, Houston, Locher, & Zizza (2011) who found that OA who met the recommended

servings of F&V had significantly lower odds of developing disability relating to IADLs, with fruit providing additional protection against developing lower extremity mobility and general disabilities.<sup>84</sup> Conversely, adults who consume less than the recommended five servings of F&V are at an increased risk of developing disability, sarcopenia, or experiencing a decrease in PF.<sup>82,86-87</sup> One study found that consuming  $\leq 1$  serving of F&V per day was found to lead to a 1.29-fold increase in risk for disability.<sup>82</sup> In a pilot cross-sectional study of OA with Type 2 Diabetes, poor nutrition was found to be associated with decreased function and lower extremity strength, with F&V intake demonstrating moderate positive correlation with lower extremity strength.<sup>88</sup> This relationship has been confirmed in OA without diabetes<sup>87</sup>, with F&V intake also demonstrating a positive correlation with IADLs and basic activities of daily living.

Multiple studies have looked at the association between intake of specific micronutrients found primarily in F&V and PF.<sup>89-90</sup> Results indicate that higher daily intakes of vitamins C and beta-carotene are significantly correlated with knee extension strength and physical performance<sup>90-91</sup>, whereas low intakes of vitamins D, E, C, and folate are associated with the development of frailty<sup>89,92</sup> and poor PF.<sup>91</sup> Carotenoids, which include  $\alpha$ -carotene,  $\beta$ -carotene,  $\beta$ -cryptoxanthin, lutein, zeaxanthin, and lycopene, have been associated with strength, walking speed, and PF in OA.<sup>93-94</sup> Low levels of plasma carotenoids are associated with greater declines in hip, knee, and grip strength<sup>93</sup>, and higher levels of plasma carotenoids are associated with fast walking speeds and less walking disability with increasing age.<sup>95</sup>

### **Interventions to Improve Diet and Physical Function**

Although there is significant evidence for a relationship between F&V consumption and PF in OA, there are few F&V intervention studies with a PF outcome published.<sup>100-101</sup> There are multiple studies with a general or protein-specific intervention to improve PF, often in combination with increased PA or weight loss, that have reported a significant improvement in PF.<sup>96-98</sup> However, one study found no significant change in PF among participants receiving a dietary intervention group,<sup>99</sup> although the results of this study may have been confounded by high levels of PF at baseline.

There have been some interventions implemented to increase F&V consumption in OA; however, only two were found that had PF as the primary outcome of the study. Those two studies were multimodal interventions--combining PA and dietary components.<sup>100-101</sup> Only one study found significant improvements in PF following an increase in PA and F&V consumption<sup>100</sup>, while the other study found no significant improvement.<sup>101</sup>

Only one intervention that solely implemented a F&V or F&V-related intervention used a subject population of OA.<sup>102</sup> Neville et al. (2013) implemented a F&V intervention, at end the of which it was found that OA who increased F&V consumption to  $\geq 5$  servings of F&V per day moderately increased grip strength, but did not significantly improve PF compared to OA who continued to consume  $\leq 2$  servings of F&V per day.<sup>102</sup> However, both the individuals who consumed  $\geq 5$  or  $\leq 2$  servings of F&V per day demonstrated a change in PA levels between baseline and post-intervention, which could confound the results, and the baseline PF scores were



within a narrow range between moderate and mild disability categories, thus limiting the maximum amount of PF improvement experienced by the subjects.

Two additional studies were identified that implemented a F&V intervention; however, the subject population consisted of young adults aged 18 to 35.<sup>103-104</sup> Both studies found no significant differences between control and treatment groups, either with a grape supplement or a F&V supplement. While the subjects for both studies were sedentary, none of them had reported limitations in PF, which is a limitation to both studies. There is limited data on the effect of increased F&V consumption in OA with poor levels of PF. Current studies increase F&V consumption in conjunction with PA or weight loss and utilize a young adult or fully functioning subject population with varied subject responses, indicating a need for further study in this field of research.

## **SELF-EFFICACY**

### **Self-Efficacy of Older Adults**

SE is an individual's belief in his or her ability to successfully perform a task.<sup>105</sup> SE often declines with increasing age as individuals associate aging with an automatic and unavoidable decline in PF.<sup>105-107</sup> Decreasing SE may limit an individual's functional ability by limiting what he or she attempts to do independently, based upon perceived capability, regardless of actual capability<sup>108</sup>, thus creating a self-fulfilling prophecy by which his/her PF declines because he/she believe it has declined.<sup>109</sup> However, when OA disassociate themselves from their age group and do not focus on being "old", they tend to have higher levels of SE, and, thus, PF than their peers.<sup>110</sup>

## **Relationship between Self-Efficacy and Physical Function**

The level of an individual's SE has been found to be significantly related to PF<sup>111-112</sup> and mortality.<sup>106,109</sup> This is supported by findings that SE mediates the effect of age on walking performance in OA<sup>113</sup> and Timed Up and Go (TUG)<sup>114</sup>, both of which are measures of PF.

Studies have demonstrated that SE plays a significant role in modulating PF.<sup>115-116</sup> Konopack et al. found that exercise SE is responsible for 44% of the variance of physical power, which was measured by the arm curl and chair stand test portion of the Senior Fitness Test.<sup>115</sup> Similar results were found in a two year observational study in which researchers discovered that among older women, PA and SE account for 47% of the variance of PF and 78% of the variance in functional limitations, independent of age, race, or health status.<sup>116</sup> SE has been shown to have a more direct influence on disability compared to functional performance and PA.<sup>117</sup>

The effects of SE on PF are mediated by PA. Higher SE is a determinant in adopting and maintaining a physically active lifestyle<sup>118-122</sup> and participating in higher intensities of PA.<sup>118</sup> This is due to the effects of an individual's SE on his/her ability to exercise for various amounts of time, overcome barriers to exercise, and recover from failures or setbacks.<sup>119-120</sup> This influence has been demonstrated across age groups.<sup>123</sup> Declining PA levels associated with increased age are also correlated with low SE.<sup>124</sup> Additionally, changes in PA levels have resulted in significant changes in SE<sup>116</sup>, with increased PA levels improving the SE of OA.<sup>122,125-126</sup> This relationship has also been demonstrated in frail and diseased OA.<sup>122,125</sup> This positive change in SE of OA due to PA may mediate the improvements in PF observed with increased PA.<sup>111</sup>

## **Interventions to Increase Self-Efficacy and Physical Function**

There are few published interventions designed to specifically improve SE in OA with the aim of improving PF. There are multiple PA interventions for OA with PF as a primary outcome and SE as a secondary outcome.<sup>127</sup> One study found that PA improved SE; however, the improvement in SE was not related to the improvement demonstrated in PF.<sup>127</sup>

Interventions that include a SE specific component for OA have resulted in increased PF<sup>125,128-130</sup> or quality of life.<sup>131</sup> SE has increased significantly following an exercise intervention for OA, which in turn was significantly related to improved PF.<sup>125,130</sup> Individuals who received a SE+PA intervention improved PF significantly more than individuals who received a PA-only intervention.<sup>129</sup> SE has been found to be a significant predictor of PF post-intervention compared to exercise alone; however, the overall intervention effect was due to the exercise component.<sup>128</sup> One study demonstrated mixed results with a PA and SE intervention resulting in improvements in the 6-Minute-Walk but not the Timed Up and Go<sup>132</sup>, both of which are commonly used outcome measures for PF in OA. A limitation of this study was the small sample size and wide range of PF scores at baseline, which could have resulted in no significant change post intervention. Another study found no improvement in PF.<sup>131</sup> This study used a subjective measure of PF instead of an objective measure, which could explain the difference in results compared to the studies previously mentioned.

These studies demonstrate the varied responses to a PA + SE intervention for OA with varied results. However, there are no studies found that implement a SE only

intervention to improve PF in this population. Thus, the varied results may be in part mediated by the PA intervention instead of the SE component in isolation. Further studies need to be developed to address this issue.

## **SUMMARY**

PA, F&V, and SE demonstrate significant relationships with PF in OA. It has been found that levels of those three variables decline with increasing age, with lower levels demonstrated by OA compared to younger adults. Many interventions to improve these three variables in OA have demonstrated an improvement in PF in this population. However, there remains variability in response to these interventions. No study has been found that assessed changes in PF to all three variables in one group of subjects. There is a need for further study to determine the efficacy of variable specific interventions and mixed variable interventions.

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